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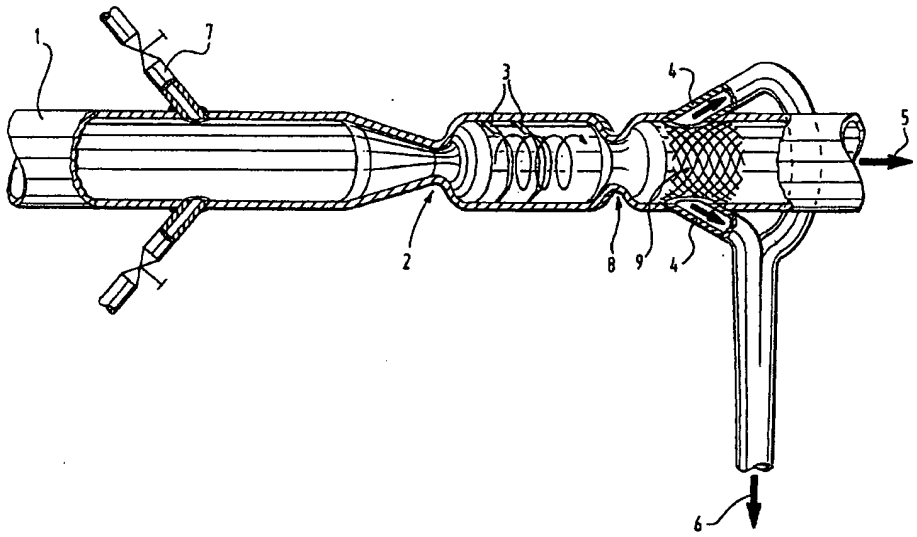
(54) Title: METHOD AND APPARATUS FOR REMOVING SOLID PARTICLES FROM A GAS



(57) Abstract: The invention relates to a method and a device for separating a substance from a gas flow, comprising of realizing a vortex in the gas flow and separating the gas flow transversely of the axial direction of the vortex into a primary partial gas flow and a secondary partial gas flow, wherein the secondary partial gas flow comprises a larger content of substance for separating than the primary partial gas flow, wherein the gas flow is accelerated to supersonic speeds prior to realizing of the vortex in the gas flow, wherein the substance to be separated comprises initially solid particles. It is significant here that the solid particles do not clog the device. This is all the more surprising as the gas flow contains components which condense in the device. Condensation will therefore take place on the particles, which will thereby become sticky.

WO 01/21286 A1

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

METHOD AND APPARATUS FOR REMOVING SOLID PARTICLES FROM A GAS

The invention relates to a method for separating a substance from a gas, comprising of realizing a vortex in the gas and separating the gas flow transversely of the axial direction of the vortex into a primary partial gas flow and a secondary partial gas flow, wherein the secondary partial gas flow comprises a larger content of substance for separating than the primary partial gas flow.

Such a method is known from WO-A-99/01194.

The method described in this document relates to removing water from natural gas before the natural gas is distributed in a pipeline network. Natural gas naturally contains water in the form of water vapour, which is undesirable in respect of corrosion or clogging. The above stated method is applied to prevent this. During performing of the method according to the invention the water vapour is condensed by cooling, thereby causing a difference in density of the gas flows, so that the effect of the method according to the present invention is enhanced.

In recent times more and more use is being made of gas turbines in the generation of electrical energy as a result of their high thermal efficiency. A gas turbine requires dust-free or virtually dust-free fuel. For the generation of such fuel it is attractive to make use of gasification of coal or other solid fuels. The gasification process generally produces a gas flow contaminated with dust particles which cannot be supplied directly to a gas turbine.

The object of the invention is to provide a method wherein solid particles can be removed from large volumes of gas without too great a pressure loss and without excessive use of energy.

This objective is achieved in that the substance to be separated comprises initially solid particles.

Tests have surprisingly shown that the method per se known in separating gases which may or may not condense also works in the separation of solid particles. It is significant here that, contrary to expectations, the solid particles do not clog the device. This is all the more surprising as the gas flow contains components which condense in the device. Condensation will therefore take place on the particles, which can thereby become sticky and cause clogging.

Solid particles are understood to mean not only dust particles, grains and other particles included in the classical definition of "solid", but also particles of viscous material, such as tar particles.

According to a preferred embodiment chemical or physical reaction agents are added to the gas flow prior to or during forming of the vortex in the gas flow.

With these reaction agents physical or chemical reactions can be excited or enhanced which result in changes in the properties of the dust particles for separating, so that the separating mechanism has a better action.

This is particularly effective when the reaction agents are suitable for enhancing the condensation on the solid particles of gases taken up in the gas flow.

According to yet another embodiment the particles are exposed to a catalyst for degrading the particles during performing of the method.

The problems of clogging which may still occur are avoided by degrading the particles.

The invention also relates to a device for separating substances from a gas flow, comprising a device for forming a vortex in the gas flow and separating means for separating the gas flow into a primary gas flow and a secondary gas flow, wherein the

secondary gas flow comprises a larger content of the substance for separating than the primary gas flow, wherein the device is dimensioned to separate initially solid particles.

According to a first preferred embodiment acceleration to supersonic speeds takes place.

When solid particles are present in the gas flow for cleaning, there is the danger of the solid particles adhering to the wall of the channels through which the gas flows move. This results in a malfunctioning device and finally to clogging. By applying supersonic speeds expansion of the gases takes place under adiabatic conditions. Cooling occurs as a result. This results in condensation of the vapour, also on the solid particles, present in the gas mixture. The particles hereby become heavier, so that the separating mechanism will function better. The stickiness of the viscous particles will moreover be greatly reduced by the forming condensation layer, so that less contamination and clogging will occur.

The invention also relates to a device wherein the acceleration device is adapted to accelerate the gas flow to a supersonic speed.

According to another preferred embodiment chemical or physical reaction agents are added to the gas flow prior to or during forming of the vortex in the gas flow.

With these measures the properties of substances for removing from the mixture can be influenced by adding reaction agents. It is hereby possible to increase the effectiveness of the separating process, for instance by enhancing condensation and reducing undesired properties, such as stickiness, of the particles for removal.

The present invention further relates to a device wherein a feed device is placed preceding the vortex for feeding chemical or physical reaction agents to the gas flow for the purpose of removing solid

particles from a gas, comprising a device for forming a vortex in the gas flow and separating means for separating the gas flow into a primary gas flow and a secondary gas flow, wherein the secondary gas flow comprises a larger content of solid particles.

According to another preferred embodiment a feed device is placed preceding the vortex for feeding chemical or physical reaction agents to the gas flow.

The effectiveness of the separating process can be hereby increased.

In order to avoid adhesion of the solid and/or viscous particles to surfaces, special coatings in the form of catalysts can be applied on the surface which, via catalytic activity, convert adhered solid and/or viscous particles into gases and/or non-viscous particles.

The present invention will be elucidated hereinbelow with reference to the annexed figure, which shows an embodiment of a device according to the present invention suitable for performing the method according to the present invention.

The device shown in figure 1 comprises a tube 1 which is provided with a first venturi 2. Downstream of the venturi 2 are arranged baffles 3 for forming of a swirl or vortex in the subsequent part of the tube.

A device 4 is further arranged downstream for separating the gas flow into a primary gas flow, which is designated with arrow 5, and a secondary gas flow, which is designated with arrow 6. Use is made here of the fact that by causing swirls or vortex the solid particles move as far as possible toward the outside of the tube.

A pump or other device is of course placed upstream to cause the gas flow. It will be apparent that it is likewise possible to place a pump downstream.

Use is made in the drawn embodiment of an additional acceleration device in the form of an extra venturi 8.

Use is further made in the device of a feed channel 7 which is suitable for feeding chemical or physical reaction agents in the form of for instance gases or vapours. As a result of this reaction it is possible to have chemical reactions occur prior to the venturi 2.

In order to prevent possible problems of adhesion of sticky, viscous particles to the walls of the device, a layer of catalyst material 9 is applied in the vicinity of the discharge channels for the secondary gas flows 6. There is after all in the vicinity of these channels the greatest likelihood of sticky particles making contact with the wall and adhering to the wall. In order to avoid the problems associated herewith, the catalyst material converts the adhered particles into fluid or gaseous material which can be readily taken up into the secondary gas flow.

Although the invention has numerous fields of application, it is intended in the first instance for cleaning flue gases originating from a gasification device. These are supplied to a gas turbine, a gas engine or a fuel cell for the purpose of generating heat and/or power. It is of the greatest importance that the gases supplied to these apparatuses are free of solid particles. The use of this separating method results in a great improvement in the effectiveness of the separation. Acceleration of the gas flow will of course result in a greater use of energy; the pumping capacity will after all have to be increased. This is more than offset however by the advantages of a clean, particle-free gas, all the more so as the flow rate of the flue gas is rather low compared to the other gas flows occurring in such processes.

According to a preferred embodiment chemical or physical reaction agents are added to the gas flow prior to or during forming of the vortex in the gas flow.

With these reaction agents physical or chemical reactions can be excited or enhanced which result in

changes in the properties of the dust particles for separating, so that the separating mechanism has a better action.

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CLAIMS

1. Method for separating a substance from a gas flow, comprising of realizing a vortex in the gas flow and separating the gas flow transversely of the axial direction of the vortex into a primary partial gas flow and a secondary partial gas flow, wherein the secondary partial gas flow comprises a larger content of substance for separating than the primary partial gas flow, wherein the gas flow is accelerated to supersonic speeds prior to realizing of the vortex in the gas flow, **characterized in that** the substance to be separated comprises initially solid particles.

2. Method as claimed in claim 1, **characterized in that** chemical or physical reaction agents are added to the gas flow prior to or during forming of the vortex in the gas flow.

3. Method as claimed in claim 2, **characterized in that** the reaction agents are suitable for enhancing the condensation on the solid particles of gases taken up in the gas flow.

4. Method as claimed in claim 1, 2 or 3, **characterized in that** the particles are exposed to a catalyst for degrading the particles during performing of the method.

5. Method as claimed in any of the foregoing claims, **characterized in that** the method is performed on combustible gases coming from a gasification installation before they are fed to a gas turbine or fuel cell.

6. Device for separating a substance from a gas flow, comprising a device for forming a vortex in the gas flow and separating means for separating the gas flow into a primary gas flow and a secondary gas flow, wherein the secondary gas flow comprises a larger content of the substance for separating, **characterized in that** the device is dimensioned to separate initially solid particles.

7. Device as claimed in claim 6, **characterized in that** a feed device is placed preceding the vortex for feeding chemical or physical reaction agents to the gas flow.

8. Device as claimed in claim 7, **characterized in that** the device is dimensioned for removal of solid particles which are at least partially viscous on their outside.

9. Device as claimed in claim 8, **characterized in that** at the locations which are highly likely to make contact with solid particles a catalyst is arranged to degrade these particles.

10. Device as claimed in claim 9, **characterized in that** a second venturi is placed upstream of the means for forming a vortex.

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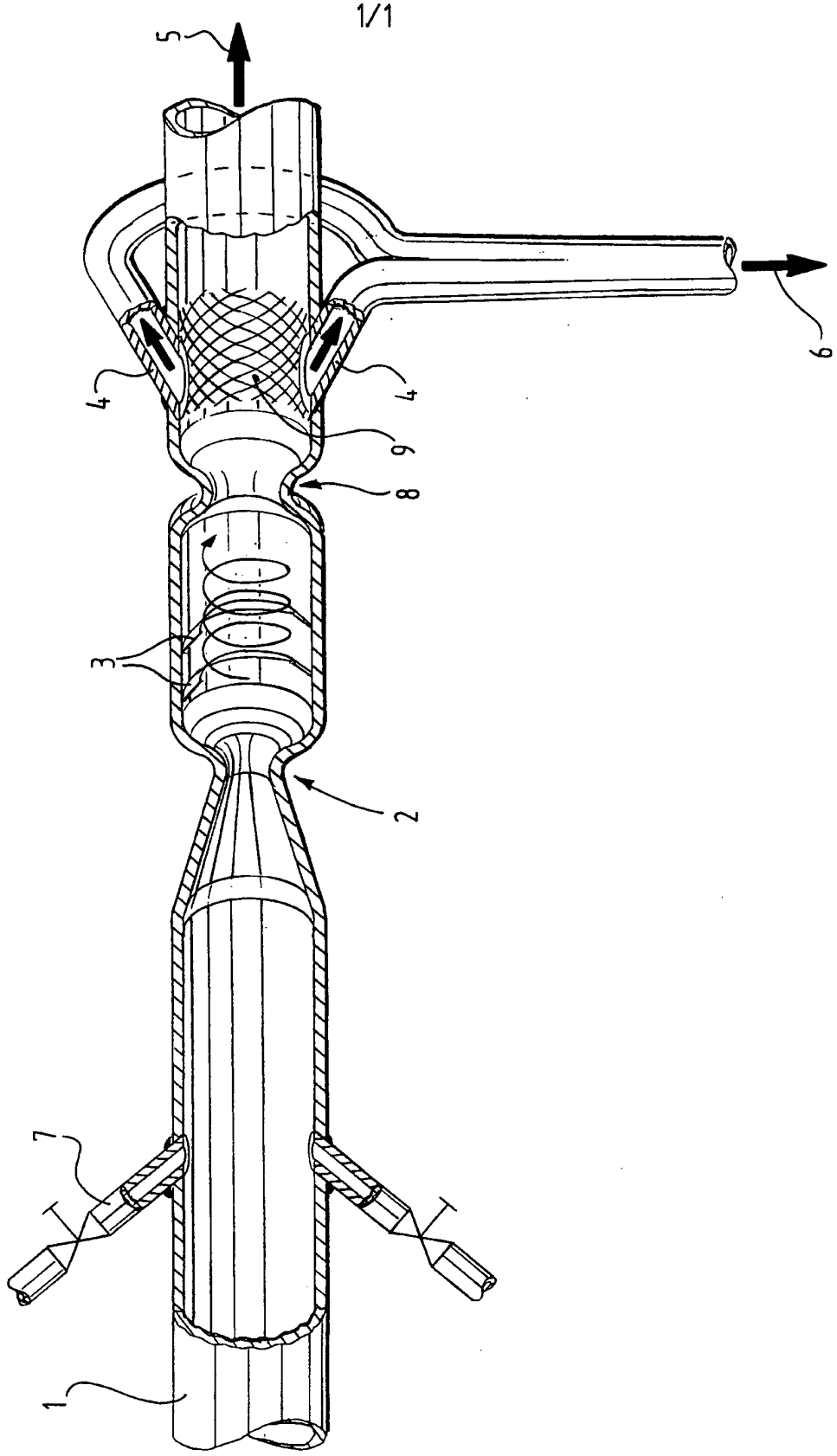
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INTERNATIONAL SEARCH REPORT

Inter nal Application No
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A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B01D B04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99 01194 A (SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B. V.) 14 January 1999 (1999-01-14) page 5, line 28 -page 9, line 34 ---	1-9
X	EP 0 496 128 A (STORK PRODUCT ENGINEERING B.V.) 29 July 1992 (1992-07-29) column 1, line 1 -column 2, line 27 ---	1,2,4,5, 7-9
X	US 4 292 050 A (LINHARDT ET AL) 29 September 1981 (1981-09-29) column 3, line 42 -column 8, line 33 ---	1,2,4,5, 7-9
P,X	WO 00 40834 A (SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B. V.) 13 July 2000 (2000-07-13) page 8, line 7 -page 10, line 13 --- -/--	1,2,6,8, 10

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 285 916 A (BAISDEN) 25 August 1981 (1981-08-25) column 4, line 18 -column 7, line 9	1,3,4,6, 10
A	GB 1 206 007 A (THE SWISS CONFEDERATION) 23 September 1970 (1970-09-23) page 1, line 69 -page 2, line 116	1,4,9,10
A	US 5 857 326 A (BLANCHET) 12 January 1999 (1999-01-12) column 2, line 25 -column 3, line 10	1,3,4,6, 10
A	WO 95 03872 A (EUROPÄISCHE ATOMGEMEINSCHAFT (EURATOM)) 9 February 1995 (1995-02-09) page 3, line 2 -page 5, line 2	1-6,9
A	US 3 894 851 A (GORMAN) 15 July 1975 (1975-07-15) column 2, line 18 -column 4, line 27	1,3,4,6, 9

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

information on patent family members

Inter nal Application No
PCT/NL 00/00670

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9901194 A	14-01-1999	AU 725574 B	12-10-2000
		AU 8857098 A	25-01-1999
		BR 9810386 A	05-09-2000
		CN 1261814 T	02-08-2000
		EP 1017465 A	12-07-2000
		NO 996546 A	29-12-1999
		ZA 9805706 A	27-01-1999
EP 496128 A	29-07-1992	NONE	
US 4292050 A	29-09-1981	NONE	
WO 0040834 A	13-07-2000	AU 2434700 A	24-07-2000
		AU 3044600 A	24-07-2000
		WO 0040835 A	13-07-2000
US 4285916 A	25-08-1981	US 4231763 A	04-11-1980
GB 1206007 A	23-09-1970	CH 472638 A	15-05-1969
		CH 470637 A	31-03-1969
		DE 1719486 A	09-03-1972
		DE 1719485 A	02-09-1971
		FR 1605133 A	16-03-1973
		FR 1605135 A	16-03-1973
		NL 6801079 A	29-07-1968
		NL 6801080 A	29-07-1968
US 5857326 A	12-01-1999	NONE	
WO 9503872 A	09-02-1995	LU 88387 A	01-02-1995
		AT 151308 T	15-04-1997
		CA 2167725 A	09-02-1995
		DE 59402392 D	15-05-1997
		DK 711197 T	15-09-1997
		EP 0711197 A	15-05-1996
		ES 2100735 T	16-06-1997
		GR 3023673 T	30-09-1997
		JP 9500822 T	28-01-1997
		SI 711197 T	31-10-1997
		US 5827350 A	27-10-1998
US 3894851 A	15-07-1975	NONE	